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GEOPHYSICS.—*Volcanic dust as a factor in the production of climatic changes.*[1] W. J. HUMPHREYS, Weather Bureau. To be published as a Bulletin of the Weather Bureau.

Geological investigations have given us a great deal of information in regard to the climates of the past, and the following tentative conclusions appear to be well established: (*a*) The climatic changes were several, probably many. (*b*) They were simultaneous over the entire earth, and in the same sense. That is, colder everywhere at the same time (climatically speaking) or warmer everywhere. (*c*) They were of unequal intensity. (*d*) They probably were of irregular occurrence, and of unequal duration. (*e*) They, at least one or more, progressed with secondary variations of intensity, or with advances and retreats of the glacial edge. (*f*) They have occurred from very early, probably from the earliest, geological ages down to the present, and presumably will continue irregularly to recur for many ages yet to come.

Many efforts have been made to find a probable and at the same time an adequate physical basis for, or cause of the climatic changes that are known to have occurred; but, one after another, nearly all have been definitely and finally abandoned, either because of inconsistency with known physical laws or because they proved inadequate to meet the conditions imposed by geological investigations.

[1] Presented in substance before the Astronomical and Astrophysical Society of America, at Cleveland, O., January 1, 1913.

Doubtless there have been several contributing causes of climatic change, but it is the specific purpose of this paper to discuss only one of these,—a cause that during historic times has often been fitfully operative, and concerning which we have much definite information.

The cause or factor in question is the presence of *volcanic dust in the upper atmosphere.*

Volcanic dust has often been mentioned as a possible cause of cold seasons. Thus in May, 1784, Benjamin Franklin (and he may not have been the first) wrote as follows:

> During several of the summer months of the year 1783, when the effects of the sun's rays to heat the earth in these northern regions should have been the greatest, there existed a constant fog over all Europe, and great part of North America. This fog was of a permanent nature; it was dry, and the rays of the sun seemed to have little effect towards dissipating it, as they easily do a moist fog, arising from water. They were indeed rendered so faint in passing through it, that, when collected in the focus of a burning-glass, they would scarcely kindle brown paper. Of course their summer effect in heating the earth was exceedingly diminished.
>
> Hence the surface was early frozen.
>
> Hence the first snows remained on it unmelted, and received continual additions.
>
> Hence perhaps the winter of 1783–4 was more severe than any that happened for many years.
>
> The cause of this universal fog is not yet ascertained. Whether it was adventitious to this earth, and merely a smoke proceeding from the consumption by fire of some of those great burning balls or globes which we happen to meet with in our course round the sun, and which are sometimes seen to kindle and be destroyed in passing our atmosphere and whose smoke might be attracted and retained by our earth; or whether it was the vast quantity of smoke, long continuing to issue during the summer from Hecla, in Iceland, and that other volcano which arose out of the sea near that island, which smoke might be spread by various winds over the northern part of the world is yet uncertain.
>
> It seems, however, worth the inquiry, whether other hard winters, recorded in history, were preceded by similar permanent and widely extended summer fogs. Because, if found to be so, men might from such fogs conjecture the probability of a succeeding hard winter, and of the damage to be expected by the breaking up of frozen rivers in the Spring; and take such measures as are possible and practicable, to secure themselves and effects from the mischiefs that attend the last.[2]

[2] See Sparks, "Life of Benjamin Franklin," 6: 455–457. (Cited in Proceedings of the Amer. Phil. Soc., 45: 127. 1906.)

The idea then that volcanic dust may be an important factor in the production of climatic changes is not new, but hitherto the idea has not been supported either by a clear explanation of the process by which such dust can lower average temperatures or by a discussion of all the available observational data. In fact the rational or theoretical discussion has not long been possible since, in almost every particular, it depends upon the results of recent investigations.

We shall now briefly consider, under separate heads, the several points essential to an understanding of how volcanic dust may influence, and of the extent to which it actually has influenced, our average temperatures—by what process it may modify and to what extent it actually has modified our climates.

Atmospheric regions. At an elevation that in middle latitudes averages about 11 kilometers the temperature of the atmosphere becomes substantially constant, or, in general, ceases appreciably to decrease with increase of elevation, this is, therefore, the upper limit of distinct vertical convection and of cloud formation. Hence, while volcanic or other dust in the lower or cloud region of the atmosphere is quickly washed out by snow or rain, that which by any process happens to get into the upper or isothermal region must continue to drift there until gravity can bring it down to the level of passing storms. In other words, while the lower atmosphere is quickly cleared of any given supply of dust, the isothermal region retains such dust as it may have for a time that depends upon the size and density of the individual dust particles themselves, or upon the rate of fall.

Size of volcanic dust particles. From the angular dimensions of a reddish brown corona, known as Bishop's ring, seen around the sun after the eruptions of Krakatoa, Pelé and certain other volcanoes, it has been calculated, by the aid of the laws of diffraction, that the average diameter of the particles to which this ring was due, assuming them spherical, was about 1.85 microns. Hence, with this information, it becomes possible to calculate the time of fall of volcanic dust.

Time of fall. By using the excellent measurements recently made by McKeehan[3] on the terminal velocity of falling globules,

[3] Phys. Rev., **33**: 153. 1911.

it is easy to show that spherical particles of volcanic dust of the size above determined would require more than a year to fall from only the maximum height already reached by sounding balloons down to the upper cloud limit. But as most volcanic dust does not consist of solid spheres, but rather of flakes and rods, and again, as much of it is finer than the size assumed, it follows that the time of fall may, in rare cases, be as much as two to four years, or possibly even longer. Obviously then volcanic dust once in the upper atmosphere must remain in it for many months and be drifted out, from whatever origin, into a thin veil covering perhaps the entire earth. Hence to find its effect on the temperature of the lower atmosphere it is necessary to determine its action on radiation, both terrestrial and solar.

Comparative action of volcanic dust on terrestrial and on solar radiations. Since those volcanic dust particles that remain long suspended in the atmosphere are large in comparison to the cube of the wave-length of solar radiation, at the region of maximum intensity, and small in comparison to the cube of the wave-length of terrestrial radiation, also at the region of maximum intensity, it is easy, by the use of equations developed by Rayleigh,[4] to compare the action of the dust on the two kinds of radiation.

This calculation shows that volcanic dust particles, of the size indicated by Bishop's ring, is roughly 30 fold more effective in shutting solar radiation out than it is in holding terrestrial radiation in. Therefore a veil of volcanic dust must produce an inverse green-house effect, and, if long continued, should perceptibly lower our average temperature. Let us see then what observational evidence we have on the effect of volcanic dust on insolation intensity and average temperatures.

Pyrheliometric records. This subject has been carefully studied by Dr. Kimball[5] of the U. S. Weather Bureau, who finds that there was a marked decrease in the insolation intensity from the latter part of 1883 (the year this kind of observation was begun) to and including 1886, from 1888 to 1892, and during 1903. There has also been a similar decrease since about the

[4] Phil. Mag., **47**: 375. 1899.
[5] Bull. Mt. Weather Obsy., **3**: 69. 1910.

DISCREPANCIES BETWEEN AVERAGE TEMPERATURES AND SUN-SPOT NUMBERS

DATE	NATURE OF DISCREPANCY	PROBABLE CAUSE
1755–56	Cold	Kötlugia, Iceland, 1755.
1766–67	Cold	Hecla, Iceland, 1766. Mayon, Luzon, 1766.
1778–89	Warm	Maximum number (annual) of sun-spots ever recorded and unusually short spot period. Can it be that the solar constant actually was distinctly greater than usual at this time?
1784–85–86	Cold	ASAMA,[1] Japan, 1783. The most frightful eruption on record. Skaptar Jökull, Iceland, 1783. Vesuvius, Italy, 1785.
1799	Cold	Fuego (?), Guatemala. (Uncertain.)
1809	Cold	St. George (?), Azores, 1808. (Uncertain.) Etna(?), Sicily, 1809. (Uncertain.)
1812–13–14–15–16	Cold	Soufrière, St. Vincent, 1812. Mayon, Luzon, 1814. TOMBORO, Sumbawa, 1815, very great.
1831–32	Cold	Graham's Island, 1831. Babujan Islands, 1831. Pichincha, Ecuador, 1831.
1856–57	Cold	Cotopaxi (?), and others, 1855–56. (Uncertain.)
1872–73	Cold	Vesuvius, Italy, 1872. Merapi, Java, 1872.
1875–76	Cold	Vatna Jökull, Iceland, 1875.
1884–85–86	Cold	KRAKATOA, Straits of Sunda, 1883, greatest since 1783. Saint Augustin, Alaska, 1883. Tarawera, New Zealand, 1886.
1890–91–92	Cold	Bogoslof, Aleutian Islands, 1890. Awoe, Great Sangir, 1892.
1902–03–04	Cold	Pelé, Martinique, 1902. Santa Maria, Guatemala, 1902. Colima, Mexico, 1903.
1912–13	Cold	Katmai, Alaska, 1912.

[1] Capitals indicate exceptional violence.

middle of 1912. Now all these decreases of insolation intensity, amounting at times to 20 per cent of the average intensity, followed violent volcanic eruptions that filled the isothermal region with a great quantity of dust.

Surface temperatures. It has been known for a long time that the number of sun-spots and the average temperature of the earth are roughly related in the sense that the greater the number of spots the lower the temperature, and the smaller the number of spots the higher the temperature. But this relation has many marked exceptions, every one of which, or at any rate all the more important ones, occurred immediately after violent volcanic explosions and presumably therefore were caused by volcanic dust.

The list on page 369 gives the more important of these discrepancies, since the beginning of sun-spot records to the present, and their probable causes.

From the above it appears quite certain that volcanic dust can lower the average temperature of the earth by an amount that depends upon the quantity and duration of the dust, and that it repeatedly has lowered it certainly from 1°F. to 2°F. for periods of from a few months to fully three years. Hence it certainly has been a factor, in determining our past climates, and presumably may often be a factor in the production of our future climates. Nor does it require any great volume of dust to produce a marked effect. Thus it can be shown by a simple calculation that less than the one thousandth part of a cubic mile of rock spread uniformly thru the upper atmosphere as volcanic dust would everywhere decrease the average intensity of insolation received at the surface of the earth by at least 20 per cent and therefore would, presumably, if long continued, decrease our average temperatures by several degrees.

CONCLUSION

It has been shown in the above, among other things, that volcanic dust in the high atmosphere decreases the intensity of solar radiation in the lower atmosphere, and therefore the average temperature of the earth, substantially as theory indicates

a priori that it should; and this effect has been clearly traced back to 1750, or to the time of the earliest reliable records. Hence it is safe to say that such a relation between volcanic dust in the upper atmosphere and average temperatures of the lower atmosphere has always obtained, and therefore that volcanic dust must have been a factor, possibly a very important one, in the production of many, perhaps all, past climatic changes, and that thru it, at least in part, the world is yet to know many another climatic change in an irregular but well-nigh endless series—usually slight tho always important, but occasionally it may be, as in the past, both profound and disastrous.

PHYSICS.—*Melting points of the refractory elements. I. Elements of atomic weight from 48 to 59.* G. K. BURGESS and R. G. WALTENBERG, Bureau of Standards. To appear in The Bulletin of the Bureau of Standards.

The elements included in this list are the iron group: nickel, cobalt, iron, manganese and chromium, and also vanadium and titanium. In subsequent papers results will be given on other refractory elements now being studied, and it is hoped eventually to include all the available refractory elements in this series of melting point determinations. The method mainly used is that of the micropyrometer[1] which, with substances that melt sharply as nickel, cobalt and iron, permits working to a precision of 1 or 2 degrees with a few thousandths of a milligram of the material.

An estimation of the melting points of the iron group elements[2] was made some years ago by a similar but less sensitive method at a time when none of these melting points was well known. The object of these earlier measurements was primarily to demonstrate the convenience and reliability of the method especially for those elements which can be obtained pure only in minute quantities. It is believed that the present series of determinations, with the improved apparatus, will contribute to a more exact

[1] A micropyrometer, by G. K. Burgess, Jl. Washington Academy of Sciences, **3**: 7. 1913. Phys. Zs., **14**: 158. 1913. Bull. Bureau of Standards, **9**: 475. 1913.

[2] Melting points of the iron group elements by a new radiation method, by G. K. Burgess. Bull. Bureau of Standards, **3**: 345. 1907.

knowledge of these melting points. The melts were made for the most part in pure hydrogen, and except for titanium, were taken on platinum strips 6 to 8 cm. long, 4 mm. wide, and 0.01 or 0.02 mm. thick. Manganese was also melted on nickel strips and titanium was melted on iridium strips.

Calibration with nickel and palladium. For melts on platinum the pyrometer was calibrated in terms of the melting points of nickel and palladium. The melting of these metals is extremely sharp on platinum and they appear to show no alloying until they melt. It is assumed that they melt on platinum at the same temperatures as in crucibles; this we have found to be the case for nickel, palladium, platinum, and iron. Numerous observations were made with various metals upon the possible effects on the melting point determinations of alloying with the platinum strip. We are convinced, that except possibly in some cases which we shall not consider here in which there may be a chemical reaction among the materials in the furnace, as for example when silicon, platinum and hydrogen are together, there is no significant alloying effect with the apparatus and materials as we use them.

The melting points of both nickel and palladium may be considered as well established by several series of measurements.[3] We have made an independent optical determination of the nickel melting point in hydrogen with an Arsem furnace.[4] The nickel was melted in a magnesia crucible contained within an out-glazed, closed-end porcelain or kaolin tube. Temperatures were measured with a Holborn-Kurlbaum form of Morse pyrometer which had been calibrated by Dr. Kanolt at the melting points of antimony (630°), Ag_3Cu_2 (779°), silver (960°.5), copper (1083°), and diopside (1391°). Five observations by Dr. Kanolt on the melting point of platinum with this pyrometer gave 1755° ± 5 in an iridium furnace, or in exact agreement with the generally accepted value.[3]

For nickel, four observations gave us 1449°, 1450°, 1449°, 1449°

[3] See Day and Sosman, Carnegie Institution of Washington, Pub. 157, 1911. Waidner and Burgess, Bull. Bureau of Standards, **3**: 163. 1907.

[4] Jl. Am. Chem. Soc., **28**: 921. 1906.

in the Arsem furnace, by the method of optical heating and cooling curves,[5] values which are close to Day and Sosman's value, 1452°. Four observations of the melting point of nickel on iridium with the micropyrometer gave us 1452°.

With the long filament pyrometer lamps used, the equation[6] $\log c = a + b \log T$ (in which c = current and T = absolute temperature and b is very nearly unity) is sufficient for very considerable temperature ranges, and permits a calibration in terms of two temperatures only, i.e., nickel and palladium. Applying this equation by extrapolation to the determination of the platinum melting point by observing the melting of platinum strips mounted as usual for taking metal melts, we obtained 1755° ± 5 from six observations. The values found for diopside (1391°) and anorthite (1549°) by Day and Sosman were also exactly reproduced by us with the micropyrometer.

The metals actually used for calibration in hydrogen were "Kahlbaum" electrolytic nickel (MP = 1452°) and pure Heraeus palladium (MP = 1549°), both of the same grade as used by Day and Sosman.[7] A sample of their palladium gave exactly the same melting point as ours. In controlling the constancy of the pyrometer lamps and studying the reproducibility of the melts some 35 observations were taken of nickel and 20 of palladium. The various metals were not studied in regular order but were mixed as indiscriminately as possible, with observations on the standard points, nickel and palladium.

Iron. Pure electrolytic iron from three sources and as many different methods of preparation was used, namely, from Prof. C. F. Burgess (99.97 per cent Fe) from Langheim-Pfanhauser Werke A. G. (99.98 per cent Fe) and from a sample (99.99 per cent Fe) prepared by Mr. J. R. Cain of this Bureau. "Kahlbaum" iron in powdered form and iron reduced on the platinum strip in hydrogen from Kahlbaum iron oxide were also used.

[5] C. W. Kanolt, Tech. Paper No. 10, Bureau of Standards, 1912.

[6] Pirani, Verh. Phys. Ges., **12**: 323. 1910.

[7] Day, Sosman and Allen, l. c. The analysis by Dr. Allen of these products gave the nickel as 99.835 pure and the palladium 99.975.

TABLE I

MELTING POINT OF IRON IN HYDROGEN BY MICROPYROMETER

Electrolytic, C. F. Burgess	1538°, 1537°, 1530°, 1534°, 1530°, 1532°
Mean	1533°
Electrolytic, Langheim-Pfanhauser	1524°, 1532°, 1534°, 1534°, 1535°
Mean	1532°
Electrolytic, Cain	1533°
Powder, "Kahlbaum"	1534°
From Oxide, "Kahlbaum"	1532°

The mean value is 1533° ± 1°. This is somewhat higher than all other recent determinations, which range from 1502° to 1532°. In the Arsem furnace, we obtained *in vacuo* 1531°, 1529°, 1531°, 1527°, and in hydrogen 1523° and 1527°.

Cobalt. The cobalt used was cobalt "Kahlbaum" in the form of powder, Kahlbaum's Würfeln, cobalt reduced in hydrogen on the platinum strip from "Kahlbaum" cobalt oxide, and a sample kindly furnished by Messrs. Day and Sosman, cut from material which had been used for their determinations and which was originally powdered cobalt "Kahlbaum,"[8] shown by Dr. E. T. Allen to be 99.951 per cent cobalt. The mean is 1477° ± 2.

TABLE II

MELTING POINT OF COBALT BY MICROPYROMETER

"Kahlbaum," powder and Würfel together; 1478°, 1479°, 1482°, 1476°, 1475°, 1476°, 1478°	
Mean	1478°
Co from the oxide "Kahlbaum"	1475°, 1478°
Day and Sosman's sample	1474°, 1478°, 1478°

Three observations taken in the Arsem furnace each gave for the melting point of cobalt 1478°. Finally two melts of cobalt on iridium gave with the micropyrometer 1477° and 1478°. The value of the cobalt point which Day and Sosman found is 1490° in a nitrogen atmosphere.

Chromium. Strictly pure chromium was not available, and it is difficult to locate exactly the melting points of an impure viscous substance. Observations were taken on two samples from

[8] Day, Sosman and Allen, l. c.

Kahlbaum and on one from Dr. H. Goldschmidt, all of a purity probably not greater than 98 per cent.

TABLE III

MELTING POINT OF (98 per cent?) CHROMIUM BY MICROPYROMETER

Kahlbaum I	1527°
Kahlbaum II	1536°, 1513°, 1513°
Goldschmidt	1514°, 1524°

As the best representative value we may take 1520°. The melting point of pure chromium, however, may well be above that of iron, as may be shown by a consideration of the well known formula for lowering the freezing point by metallic impurities. On the other hand, the value 1520° may be more nearly correct if the oxides present do not lower but raise the chromium melting point as was found in the case of vanadium by Ruff and Martin.[9] If chromium is melted, for example, in a slightly oxidizing atmosphere or in impure hydrogen, an apparent melting point above that of platinum may be obtained.

Manganese. We have not been able to obtain pure manganese, and the impure samples from Kahlbaum and from Goldschmidt are even more sluggish than chromium. The Goldschmidt manganese was from a sample of about 97.5 per cent pure. Melts were taken both on platinum and on nickel strips with the micropyrometer using gold (1063°) and palladium as calibration points. Those on nickel were less satisfactory, due apparently to evaporation of nickel.

TABLE IV

MELTING POINT OF (97.51) MANGANESE BY MICROPYROMETER

Kahlbaum	on Pt., 1242°; on Ni 1221°
Goldschmidt	on Pt., 1261°, 1264°, 1279°; on Ni 1254°

The mean is 1254°, which is probably lower than the melting point of strictly pure manganese by 20°.

Vanadium. Dr. v. Wartenberg of Berlin kindly sent us some 97 per cent vanadium prepared by him from the suboxide by

[9] Ruff and Martin, Über reines Vanadin. Zs. Angew. Chem., **25**: 49. 1912.

the alumino-thermic method with calcium; it contains traces of Ca, Al and Fe. Professor Wedekind of Strassburg also furnished us with a sample of his 97 to 98 per cent vanadium. We have also examined two samples purchased from Kahlbaum at different dates. None of the samples melts sharply, the substance being viscous; all samples show evidences of incipient melting many degrees below the temperature at which the melting is complete.

With the Kahlbaum samples, evidences of melting were apparent as low as 1500°; melting was complete at about 1720°, the samples showing evidences of non-homogeneity of composition.

With Dr. v. Wartenberg's and Professor Wedekind's vanadium the following results were obtained:

TABLE V

MELTING POINT OF 97 PER CENT VANADIUM BY MICROPYROMETER

97 to 98 per cent V from Wedekind.....1700°, 1757°, 1773°, 1717°
97 per cent V from v. Wartenberg; 1680°, 1691°, 1691° (pieces of about 0.001 mg.), 1685°, 1699°, 1705° (medium sized pieces), 1725° (largest pieces).

Evidences of incipient melting were apparent at about 1650° with these materials. Other determinations of the vanadium melting point range from 1680° to 1750°. We would place the vanadium melting point at about 1720°, both from a consideration of our own and of other determinations.

Titanium. Prof. M. M. A. Hunter, of Rensselaer Polytechnic Institute kindly placed at our disposal a sample of pure titanium, which he had prepared from material furnished by the Titanium, Alloy Manufacturing Company of Niagara Falls. This titanium, analyzed by Professor Hunter, contains only a trace of iron and no other detectable impurity. Professor Wedekind likewise kindly sent us two samples prepared by him of 94 to 95 per cent purity and one by Dr. v. Wartenberg. The colloid titanium of Wedekind melted at 1508° to 1451°, and his powdered titanium at 1452°. We also took observations on two samples from Kahlbaum, which were evidently quite impure, showing evidences of an extended melting range. For the Kahlbaum samples the following melting points were obtained: 1664°, 1724°, 1677°, 1737°, 1641°. The titanium of Hunter and of v. Wartenberg showed

no signs of melting on platinum; their melting points were taken on iridium strips.

TABLE VI

MELTING POINT OF TITANIUM BY MICROPYROMETER

Ti From Professor Hunter	1790°, 1785°, 1785°
Mean	1788°
Ti From Dr. v. Wartenberg	1778°, 1807,° 1815°
Mean	1800°

These melting points are fairly sharp, and the location of the temperature was made by calibrating the micropyrometer for the iridium strip by taking observations on it of the melting of palladium (1549°), and of platinum (1755°).

Summary. We have shown that the micropyrometer may be made an instrument of precision for the determination of the melting points of refractory metals and salts; that in the case of the metals examined, the effect of alloying of microscopic particles on platinum and iridium is inconsequential until after melting which we have shown for nickel, cobalt and iron to occur at the

TABLE VII

MELTING POINTS OF ELEMENTS OF ATOMIC WEIGHT 48 TO 59

METAL	MELTING POINT WITH MICROPYROMETER	PURITY	PROBABLE MELTING POINT OF PURE ELEMENT
		per cent	
Nickel	1452°*	99.83₁	1452° ± 3
	1449†		
Cobalt	1477 ± 2	99.95₁	1478° ± 5
	1478 ± 1‡		
Iron	1533 ± 1§	99.98 ± 01	1530° ± 5
	1528 †		
Manganese	1255	97 to 98	1260° ± 20
Chromium	1520	98 to 99	1520° to > Fe
Vanadium	1720	97 to 98	1720 ± 20
Titanium	1794 ± 12	99.9+	1795 ± 15

* Assumed value on platinum strip; also observed value on iridium strip.

† Crucible melts in electric furnace.

‡ Crucible melts in electric furnace; also on iridium strip with micropyrometer.

§ Five samples all agreeing to within 3°.

same temperature for minute particles on the strips as for considerable quantities in crucibles of magnesia.

Assuming the melting points of nickel to be 1452°, palladium 1549° and platinum 1755°, and the calibration curves of the pyrometer lamps of the form $\log c = a + b \log T$, for the range here studied, we have determined the melting points of Fe, Co, Cr, Mn, V and Ti with the micropyrometer and of Ni, Co and Fe in quantity in the electric furnace, all melts having been taken in pure hydrogen and Fe also *in vacuo*. For Cr, Mn and V, strictly pure materials were not available, and we can but estimate the melting points of the pure elements.

In the complete paper, the method is discussed more in detail and photomicrographs are given showing characteristics of the various melts.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE BOTANICAL SOCIETY OF WASHINGTON

The 89th regular meeting of the Botanical Society of Washington was held on May 6, 1913, at the Cosmos Club with twenty-four members and two guests present.

The following papers were presented:

The effect of the recent freeze in California (illustrated): Dr. DAVID GRIFFITHS. Dr. Griffiths discussed the effect of the January freeze on vegetation of the southwest, with special reference to California. The main regions where tropical and subtropical things are being grown were visited. He showed 40 lantern slides made from negatives taken in February and March, showing injuries to citrus fruits, avocados, cherimoyas, mangoes, carobs, acacias, olives, eucalyptus, etc.

While the temperatures were unusually low, there are indications that they have been lower in the remote past. That such cold spells of weather are very infrequent is proved by the fact that such natives as Rhus laurina, eriogonums in California, and the giant Cereus, scholla, Celtis, Olneya, etc., in southern Arizona are severely injured. Many introduced trees which had attained a diameter of 3 feet were killed outright. Injuries were very severe thruout all of the citrus regions, but even where the temperatures went to 10–17° Fahr. in general thruout a region, an occasional orchard situated upon an abrupt elevation above the general plain escaped with even unfrozen fruit. Because of differences in elevation, air-drainage and exposures, conditions are exceedingly varied and present some of the most important problems in connection with the relation of climatic conditions to crop development. At no time in the present generation has there been such an opportunity to determine the adaptability of the scores of introduced plants of the Pacific Coast region. Thru some of the various agencies operating in agricultural lines a careful survey should be made the present season to systematize and place on record the results of a condition which, altho of infrequent occurrence, is nevertheless of the utmost scientific and economic import.

The method of types applied to the nickernut: Mr. H. C. SKEELS. Mr. Skeels called attention to the last sentence of division (e) under Canon 15 of the American Code of Botanical Nomenclature, which reads as

follows: "The genera of Linnaeus' Species Plantarum (1753) are to be typified thru the citations given in his Genera Plantarum (1754)." Under this clause the following genera were mentioned:

GENUS	TYPE SPECIES	NOW REFERRED TO
Alpinia	*A. racemosa*	Renealmia
Cerbera	*C. ahouai*	Thevetia
Crataegus	*C. aria*	Sorbus
Cucurbita	*C. lagenaria*	Lagenaria
Glycine	*G. apios*	Apios
Hibiscus	*H. malvaviscus*	Malvaviscus
Jatropha	*J. manihot*	Manihot
Medicago	*M. radiata*	Trigonella

Applying the method of types to the nickernut, Mr. Skeels called attention to Mr. Trimen's identification of the Flora Zeylanica specimens which are published in volume 24 of The Journal of the Linnean Society, Botany. On the basis of these identifications, Mr. Skeele concluded as follows:

"In conclusion, going back to our three original species, the 'Catti kitsjil' of the East Indies, the *Caesalpinia nuga* (L.) Aiton of the floras, under the method of types of the American Code, becomes *Caesalpinia crista* L., the type being Fl. Zeyl. 157. The common grey-seeded nickernut generally known as *Caesalpinia* or *Guilandina bonducella*, becomes *Guilandina bonduc* L., the type being Fl. Zeyl. 156. And the yellow-seeded, large-leafletted nickernut, generally known as *Guillandina bonduc* becomes *Guilandina major* (DC.) Small, being based thru De Candolle, on *Guilandina bonduc* L. Species Plantarum, ed. 2."

What would be the effect of the Arctic night on tropical or subtropical vegetation? Dr. F. H. KNOWLTON. Dr. Knowlton called attention to the ancient floras of the North Polar region. Many of the fossil plants found there are of a tropical or subtropical character. No satisfactory explanation of the relation of such plants to the conditions of light and darkness supposed to have prevailed has been found. Dr. KNOWLTON asked for suggestions from the members of the Society and a brief discussion followed.

C. L. SHEAR, *Corresponding Secretary.*

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